RESTRICTED CIRCULATION

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AGRICULTURAL MEMORANDUM NO. 573

A PRIMER OF WORK OPTIONS - C V SMITH

INTRODUCTION

What work should we do, and why?

These questions inevitably arise from time to time at Met. O 8a outstations, where the work proceeds in relative isolation, and is basically self directed.

There is a cardinal requirement to be aware of broad aims, and to have some schema within which more detailed work can be located. But also there is a recurring need to decide the form and direction that new work should take. This paper is intended to list some alternatives, though this or any similar attempt could not pretend to be definitive.

Memorandum No. 357 - The organisation of meteorological advice for agriculture and industry - was essentially concerned with management aims and attitudes; it dealt with some of the implications that follow from regarding meteorology as a business whose organisation requires technology as much as science, if it is to meet current measures of performance.

Memorandum No. 544 - Strategies for research and development programmes in agriculture - set out to examine the general steps in any R and D programme, to be fairly specific about procedures in agriculture, and to suggest a strategy most likely to identify key areas for the work of the agricultural meteorologist. Criteria for assigning priorities and deciding between alternative work programmes were also put forward.

The present Memorandum - A primer of work options - is a continuation of these earlier papers. It represents a further move down through the questions that finally decide what detailed work should be done. Hopefully it brings us to some real problems of the grower and his advisers, and to problems to which working solutions are required.

One objective here then is simply to examine, in a systematic way, the factors and mechanisms that affect the efficiency with which resource and energy inputs into agricultural production systems are used. Our interest extends from the fundamental, internal mechanisms and processes of plants, animals and soils, to the response to, and interaction with, impressed environmental events, and beyond, to the constraints imposed on output and management alternatives by geography, climate and the natural biological hazards of intensive farming systems. The term production is taken to include: storage, distribution, processing, the disposal of waste products and even marketing.

In WMO Technical Note No. 119 - The application of micrometeorology to agricultural problems - we have an invaluable contribution to our topic. In the Note, physical processes in the boundary layer constitute the prime, column elements in a matrix in which the row elements are comprised by the soil, plant, animal and atmospheric sciences. Each combination in the array is considered in relation to a generalised classification of farming problems.

By contrast, this paper tries to see matters from the view point of the agriculturalist. A second objective is not to present a further multi-dimensional matrix that brings out the meeting point of different sciences and processes with agriculture, but rather to suggest a series of pathways that begin at a farm commodity (or resource) and which, if explored, should end with a useful comment on its efficient production (or utilisation). The physical analogy is with a branch-chain process, where movement from one level to the next results in a gathering of momentum over a greater number of diverging tracks, and finally a multitude of end products and end points.

In using the primer, one should proceed through the sections in sequence, considering the areas suggested for examination at each step. The thesaurus at the end is intended to provide a further check list of topics for consideration.

Meteorological Office
CAMBRIDGE

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1. COMMODITY OR RESOURCES

(i) Land.
Crops.
Animals.

(ii) Labour - men.
- men and machines.

(iii) Capital (Fixed) Equipment.

(iv) Capital.

2. SPECIFIC COMMODITY OR RESOURCE

(i)	Land	- geographical location. - soil series.
(ii)	Arable crops	- Cereals. roots. forage. brassica. legumes. seed crops.
(iii)	Horticultural crops	- field crops. glasshouse crops. top fruit. soft "
(iv)	Grassland crops	- forage crops. seed crops.
(v)	Animals	- beef. dairying. pigs. poultry. sheep.

3. CONSIDERATIONS OF SCALE

(i) Time

Absolute duration or interval	- minute. hour. day. pentad. week. month. season. year. sample of years. decades or longer.
Significant biological time interval	- phenological dating. time interval between growth stages. time above or below threshold values of environment or growth parameters. length of growing season. time available. frequency of occurrence. field work days.
Change with time	- trend. response time. rate of response. acclimatisation. adaptation.
Timing	- timeliness. dating tolerance. dating control of farm operations. phase. relative phase of simultaneous processes. consequences of re-phasing.
Farming tactics	- individual farm. regionally. nationally.
Farming strategies	- individual farm. regionally. nationally.

(ii) Space

Location	- boundary layer. meso-scale. region. country. international.
Geography	- latitude. longitude. maritime. continental. proximity to semi-permanent. features of general atmospheric circulation. climate zone.

Land form - slope.
aspect.
orientation.

plain.
hill.
mountain.

coast.
estuary.

exposure.

4. PROCESS FOR STUDY - internal mechanisms.

For Commercial crop.
For Biological competitors or predators.

Understanding is required of:

(i)	Physiological processes	- requirements, and limits of acceptable range, for successive stages of life or production cycle.
(ii)	Physical processes or physical status	- requirements, and limits of acceptable ranges, for successive stages of life or production cycle.
(iii)	Physical yield	- energy assimilation.
(iv)	Economic yield	- assimilate partition. - quality.

5. PROCESS FOR STUDY - interaction with the environment.
- exchange processes.

The objective here must be the understanding and development of relationships involving both controlled and uncontrolled (environmental) inputs which indicate the nature, character and magnitude of the response of the farm and field process. This response may be measured in biological terms, in purely physical terms (e.g. the feasibility or advisability of field work; rate of working, etc.) or in terms of the environmental demand on, and for, capital equipment (e.g. sizing of equipment; frequency of use).

(i) Physical exchange processes - radiation.
heat.
momentum.
water.
carbon dioxide.
other materials.
physical status.

(ii) Chemical exchange processes.

(iii) Environment specification - relevant environmental variables.

- land capability.
- physical hazards to production.
- biological hazards to production.

(iv) Physical yield
Physical output

- energy assimilation and the quantitative response to physical factors of the environment, alone, or in combination.
- models of crop growth.
- crop forecasting.

- quantitative response to biological competition.
- demand on equipment.

(v) Economic yield

- assimilate partition as a function of:

(a) applied physical factors.

(b) nature of nutrient (energy) supply.

- quality.

6. OPTIMISATION OF MANAGEMENT DECISIONS INVOLVING ENVIRONMENTAL CONSTRAINTS

6.1 Economic strategies - physical responses.

(i) Determination of existing land capability and climate characteristics to indicate direct potential for economic yield.

Decisions on - appropriate land-use.
farming type.
farming method.
scale of capital investment to cope with the vagaries of the seasons.
crop species.
animal species.
product mix.
labour requirements.
- on risk involved in such decisions and level of "insurance" appropriate.
cost of doing nothing.
cost of protection.

(ii) Determination of land and climate characteristics in order to assess the potential for biological hazards and indirect effects on farm yield.

(iii) Increase of land and climate potential for yield.

Modifications which mediate the effects of the natural environment, and which result in a closer match with the requirements of plants and animals (both species and varieties) for optimum production.

Decisions on - irrigation.
soil conditioning.
drainage.
fertilisers.
farm stores.
shelter.
shading.
soil cover.
crop cover.
frost protection.
cost of protection.

Husbandry routines that reduce the biological competition between individual crop plants or animals, or which result in a greater or more efficient energy uptake.

- plant spacing.
- plant geometry.
- group size.

Hygiene routines that reduce biological competition of non-crop species or the challenge of predacious organisms.

Decisions on - biological.
chemical.
mechanical control measures.

Modifications that enable the introduction of higher yielding exotic species.

(iv) Increase of plant or animal potential for yield.

Increase of efficiency of fundamental physiological processes of energy assimilation and partition by:

(a) Genetic planning and breeding programmes which change the character, magnitude or rate of response to applied physical factors and energy inputs, or the susceptibility to biological competitors or predators.

(b) Control of the progression from phase to phase of the normal life or production cycle.

(c) Rephasing the 'normal' cycle of production or growth to achieve greater use of uncontrolled environmental inputs.

(d) Control of the physiological response to adverse environmental inputs which, untreated, result in stress.

6.2 Economic Strategies - management responses.

(i) Application of Systems Analysis for individual commodities.
for whole farm enterprises.

(ii) Use of mathematical modelling generally to help solve complexities of parts of,
of complete, production systems.

- simulation.
optimisation.
heuristic approaches.

(iii) Use of mathematical modelling (of both physical and economic systems) to help identify areas where quantitative relationships are not available and so to help make logical decisions about research priorities.

(iv) Development of systems for monitoring,
for forecasting,
direct environmental inputs into production systems.

(v) Development of systems for monitoring,
for forecasting,
environmental inputs of significance to the life cycle and challenge of biological competitors or predators.

Economic Tactics

(i) - choice of crop variety.

(ii) - choice of animal breed.

(iii) - timing and nature of cultivations.
- use of farm machinery generally.
- timing of field operations.

(iv) - application of monitoring/forecasting systems generally, for incidence/severity of biological challenge.

(v) - application of monitoring/forecasting systems generally, for incidence/severity of environmental constraints.

for type and timing of harvest.
(hay vs Silage.)
(grain maize vs Silage maize.)
for type of storage system.
for nature and urgency of field cultivations and field operations generally.

(vi) - application of monitoring/forecasting systems generally, for incidence/severity of environmental hazards.

(vii) - marketing; ' relating demand to environmental factors;
relating supply to environmental factors.

(viii) - inventory control.

(ix) - allocation problems.

7. A THESAURUS OF TOPICS OF AGRO-METEOROLOGICAL INTEREST

Animals

geographical distribution.
breed.
physiology.
fertility.
gestation.
growth.
time to nominated weight gain.
interval between reproduction.
fecundity.
carcase grading.
lactation.
quality.

transport.
waste disposal.

hygiene.
diseases.
disease transmission.
disease vectors.
parasites internal.
parasites external.

nutrition.
malnutrition.
feed.
energy intake.
ration mix.
digestibility.
metabolism.
energy equivalent of weight gain.

energy balance.
environmental stress.
hierachy of needs.
social environment.
behaviour.
group size.
individual response to environment.
group response to environment.
floor space per animal.
house volume space per animal.

Biological Hazards

Pollutants - air borne.
water borne.
soil borne.
concentration.
source.

Diseases - forecast.
vectors.
transmission.
challenge.
foci.
deficiency.
occupational.
metabolic disorders.

Pests
Mites
Fungi - direct effects.
- aflatoxins.
Bacteria - aerobic.
anaerobic.

Insects
Virus
Parasites

Hygiene
Biological control
Chemical control - herbicide - application
fungicide effectiveness
pesticide persistence
side effects

Chemosterilants.

Capital Equipment

Buildings - permanent.
temporary.
collapsible.
glass.
plastic.
heat exchange - insulation.
moisture exchange.
shelter generally (including living Shelter).

stores.
silos.
chitting house.

stock.
stock yard.
stock enclosures.

Machinery - ploughing.
deep tillage.
chemical cultivation.
cultivations.
harvesting.
field hygiene.

drying grass.
hay.
grain.

cooling.
chilling.
refrigerating.

artificial illumination.

fans.
ventilation.
ducting.
air distribution.
air change rate.

Crops

geographical distribution.
species.
genotype.
seed.
germination.
vegetative growth.
inflorescence.
pollination.
fruit.
growth stage.
limitations to growth.
propagation.

transport.
waste disposal.

seed bed.
cultivations.
sowing.
harvest.
damage at harvest.
crop forecast.
crop rotation.

storage.
dormancy.
sprout inhibition.

plant protection.
hygiene.
diseases.
disease vectors.
disease transmission.
parasites.
pests.
defoliation.

catch crop.
cover crop.

nutrition.
photosynthesis.
assimilation.
net assimilation.
respiration.
transpiration.
photo period.
water usage.
water loss.
plant reserves.

plant density.

response to internal chemicals.
response to applied chemicals.
phytotoxicity.

plant spacing.
mutual shelter.

growth models.
leaf arrangement.
leaf geometry.
relative growth rate.
leaf area index.
leaf growth rate.
root growth rate.
leaf area duration.
dry matter distribution.

winter survival.
vernalisation.

Data Analysis

analysis of variance.
accuracy.
amplitude.
arithmetic mean.
bias.
coherence.
contingency table.
curve fitting.
correlation.
diurnal variation.
dispersion.

error.
probable error.
extreme.
frequency.
frequency distribution.

harmonic analysis.
least squares analysis.
moving average.
periodicity.
persistence.
probability.
physical meaning.
phase.
return period.
rate - change with time.
     - change with geographical location.
range.
random sampling.

smoothing.
significance tests.

time series.
trends.

mathematical modelling.
analogues.
conservation of physical quantities.
extrapolation.
optimisation techniques.
linear programming.
network analysis.

Environmental Element

Radiation
- wavelength.
- spectrum.
- absorption.
- turbidity.
- dispersion.
- solar altitude.
- albedo.
- emission.
- total.
- direct.
- diffuse.
- Bowen ratio.
- sunshine.
- light saturation level.
- flux density.

Snowfall
- melt.
- ablation.

Rainfall
- soil moisture.
- field capacity.
- evaporation.
- transpiration - potential.
  - effective.
  - accumulated.
- surface moisture.
- surface wetness.
- irrigation need.
- drop size and rate.

Dewfall
- dew point.
- guttation.
- condensation.

Temperature
- air.
- plant.
- leaf growing point.
- soil.
- earth.
- skin.
- organism.
- feed.

- black body.
- screen (shade).
- grass minimum.
- bare soil.
- wet bulb.

- accumulated.
- "heat units".
- "cold units".
- gradient.
- lapse.

Wind - speed.
run of.
boundary layer.
surface roughness.
eddy spectrum.
eddy flux.
gust.
gust spectrum.
air movement - internal.
external.
air volume flow.
air change rate.
air distribution.
laminar flow.
permeability.
funnelling.

Moisture content - relative humidity.
vapour pressure.
saturation vapour pressure deficit.
dew point.

Synoptic - type.
situation.
analogue.
adrection.

Fog.
Mist.
Thunder.
Strong winds.
Cloudiness.
State of ground.

Days suitable for specific operations - cultivations.
spraying.
hygiene.
harvesting.
field wilting.
field drying.
of given rainfall amount.

Generally, days above or below threshold or critical values.

Day length.
Length of frost free period.
Length of growing season.

Time to reach threshold or critical values.

Environmental Hazard

Water erosion.
Flood.
Anaerobic soil.
Poaching.
Rate of rainfall.
Capping.
Run-off.

Gale.
Wind - chill.
deformation.
erosion.
dessication.
eddies.

Snowfall.
Frost.
Frost heave.

Heat stress.
Cold stress.
Moisture stress.
Metabolic disorders.

Ion type.
concentration.

Hail.

Land

Atlas.
Survey.
Site selection.
Soil - series.
classification.
mapping.
utilisation.
structure.

Soil - tillage.
deep tillage.
cultivations.
compaction.
smearing.
working conditions.
trafficability.

Shelter
Soil - weathering.
erosion.
stabilisation.
reclamation.
modification.

Soil water - catchment area.
movement.
permeability.
replenishment.
infiltration.
run-off.
available.
content.
deficit.
irrigation.
irrigation need.
sub-irrigation.
usage by crop.
drainage - feasibility.
effectiveness.
need.
worthwhileness.
water table.

panning.
acidity - ph.
salinity.

fertilisers.
available nutrients.
leaching.
rooting depth.